CANADA

DEPARTMENT OF TRANSPORT

CANADIAN
BULK CARGOES CODE

MARINE REGULATIONS BRANCH

NAUTICAL AND PILOTAGE DIVISION

OTTAWA

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DEPUTY MINISTER OF TRANSPORT
SOUS-MINISTRE DES TRANSPORTS
OTTAWA, CANADA

YOUR FILE
VOTRE RÉF:

IN REPLY QUOTE
RÉF. À RAPPELER:

In September 1965 the Inter-Governmental Maritime Consultative Organization (IMCO) appoved a Code of Safe Practice for Bulk Cargoes and recommended that it be adopted by member Governments or used as a basis for national regulations.

As a member of IMCO, Canada contributed to the development of the recommendations of the IMCO Code. To make it suitable for use in Canada it has been necessary to supplement the original text by including provisions relating to the functions of Port Wardens.

The resulting Canadian Bulk Cargoes Code, which supersedes the Canadian Concentrates Code, is a combination of the IMCO Code, some of the requirements of the Canadian Concentrates Code and the results of studies made by the Canadian Technical Committee on the Shipment of Ore Concentrates.

This Code is recommended not only for its obvious application as the approved practice envisaged by the Canada Shipping Act but as a statement of practice contributing to the safe carriage of all bulk cargoes which, by their nature, may hazard the ships which bear them.

J. R. Baldwin

(J. R. Baldwin)
Deputy Minister.

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Introduction

This Code is intended to set a standard for the safe stowage and carriage of bulk cargoes including ores and similar bulk cargoes, concentrates and similar materials. It shall be adopted for use in all Canadian ports and shall apply to all shipments of bulk cargoes to which the relevant sections of the Canada Shipping Act and the Acts respecting the Offices of Ports Wardens in Montreal and Quebec apply.

With the exception of concentrates and similar materials, the bulk cargoes dealt with in this Code are not subject to routine survey and certification before the ship in which they are carried puts to sea. However, there is a requirement that every ship be seaworthy and that the master, owner and agent take all reasonable precautions incidental to the proper stowage of cargo.

Where in the Acts, reference is made to "approved practice" and "proper stowage" this Code will be considered to set the standards of approved practice and proper stowage.

The code does not concern itself with the commercial aspects of the carriage of bulk cargoes, contamination of other cargoes, corrosion of the vessel, etc. These matters are dealt with in some detail in standard textbooks.

In general, the hazards to safety which may be encountered when carrying cargo in bulk, may be considered to fall into three categories:

A. Improper weight distribution resulting in structural damage;
   (a) Excessive concentration of weight on decks or on inner bottom,
   (b) Improper distribution of weight between holds.

B. Improper stability or reduction of stability during the voyage:
   (a) Excessive stability resulting in violent rolling with attendant possible structural damage and/or cargo shift,
   (b) Reduction of stability as a result of:
      (1) a transverse shift of the cargo surface, as in the case of "dry" cargoes and of cargoes which do not become fluid when wet, or
      (2) a transverse shift of the cargo, as in the case of "wet" cargoes which become fluid.

C. Spontaneous heating:

   In common with some other cargoes a few of the commodities covered by this Code are subject to spontaneous heating.

Information on "dry" bulk cargoes is given under the heading of "ores and similar bulk cargoes" and information on "wet" bulk cargoes is given under the heading of "ore concentrates".

Provisions of this Code of safe practice relating to the carriage of bulk cargoes apply when such cargoes are a considerable part of the total cargo for the voyage. When bulk cargoes, except ore concentrates, make up less than one-third of the cargo deadweight of the vessel, the shipmaster, at his discretion, may depart from the portions of the Code that are not considered to apply.

So that no experience from which it is possible to glean valuable information on the behaviour of shipments of concentrates should be lost, the Department has prepared a questionnaire which will be placed aboard each vessel loading bulk concentrates at Canadian ports for ocean shipment. Vessels arriving at Canadian ports with concentrates for discharge will also be contacted by the Port Warden and the Masters asked to complete the questionnaire. (See Annex III)

Individuals and organizations who feel that their acquaintance and experience with bulk cargoes including ores and similar bulk cargoes, concentrates and similar materials, may be of specific value and could contribute to a general knowledge of the whole subject, are cordially invited to contribute their opinions to the Department. Information relating to bulk cargoes which have proven hazardous is particularly welcome.

Extract from the Canada Shipping Act

Section 624(4)

The master or agent of any ship intending to load concentrates consigned to any place outside of Canada and not being a place within the limits of an inland voyage shall make application to the Port Warden, who shall survey and approve stowage according to approved practice, when the quantity of concentrates proposed to be carried exceeds eighteen per cent of the total cargo-carrying capacity of the ship; the Port Warden shall enter in his books a statement showing manner of stowage and securing, and issue a certificate accordingly.

Section 626(1)

The master of any ship either wholly or partly laden with grain, except as provided for in sub-section (5) of section 624, or with a timber deck cargo, or with concentrates, when the amount of concentrates carried exceeds eighteen per cent of the total dead weight carrying capacity of the ship, consigned to any place outside of Canada and not being a place within the limits of an inland voyage, shall, before proceeding on his voyage or clearing at the Custom House, notify the Port Warden, who shall then proceed on board such ship and examine whether she is in a fit state to proceed to sea.

Section 626(2)

Where she is found fit the Port Warden shall give a certificate accordingly and where she is found unfit, the Port Warden shall withhold certificate and notify the master or agent of the ship, detailing his requirements in accordance with regulations and approved practice.

Section 628(1)

No officer of Customs shall grant a clearance to any ship wholly or partly laden with grain except as provided for in subsection (5) of section 624, or with a timber deck cargo, or with concentrates, as defined in subsection (4) of section 624, consigned to any place outside of Canada and not being a place within the limits of an inland voyage, unless the master of such ship produces to him a certificate signed by the Port Warden, that the Regulations for the Loading and Carriage of Grain Cargoes, or Timber Deck Loads as the case may be, have been complied with, or that concentrates have been loaded and secured according to approved practice.

Section 644

(1) Every master of a ship failing to notify the port warden as required by this Part and every port warden, who, upon such notification, fails to comply with all the provisions of this Part is liable to a fine not exceeding eight hundred dollars.

(2) For any breach of the regulations for the loading and carraige of cargo or for the neglect of taking all reasonable precautions incidental to the proper stowage of cargo, the master, owner or agent of the ship responsible for the breach or neglect is liable to a fine not exceeding one thousand dollars.

(3) If any master or person at that time in charge of any ship previous to the final departure of such ship from a place in Canada, or after the arrival of such ship at her port of discharge in Canada, having on board a cargo that by its nature would constitute a danger if improperly stowed, prevents or attempts to prevent any port warden or collector of Customs from proceeding on board or from examining into the manner in which the cargo is stowed, or fails or refuses to render to that officer all reasonable assistance, he is for each offence liable to a fine not exceeding two hundred dollars. 1934, c. 44, s. 636.

Extract from "An Act to amend and consolidate the Acts relating to the office of Port Warden for the Harbour of Montreal."

45 Victoria, Chap. 45, Section 16.

The master of every vessel loading at the Port of Montreal for any port not within the limits of inland navigation, shall, before proceeding on his voyage, or clearing at the custom house for the same, notify the Port Warden, whose duty it shall then be to proceed on board such vessel and examine whether she is in a fit state to proceed to sea or not; if she is found unfit, the Port Warden shall state in what particulars, and on what conditions only she will be deemed in a fit state to leave, and shall notify the master not to leave the port until the required conditions have been fulfilled; and in case of the master refusing or neglecting to fulfil the same, the Port Warden shall notify the Collector of Customs, in order that no clearance may be granted for the vessel until such required conditions have been fulfilled, and a certificate thereof granted by the Port Warden or his Deputy.

Extract from "Rules and By-Laws of the Office of Port Warden of the Harbour of Quebec" (1953, page 34), made under 34 Victoria, Chapter 33, Section 5.

Concentrates cargo

The master or agent of any ship intending to load concentrates consigned to any place outside of Canada and not being a place within the limits of an inland voyage shall make application to the Port Warden, who shall survey and approve stowage according to approved practice, when the quantity of concentrates proposed to be carried exceeds eighteen per cent of the total cargo-carrying capacity of the ship. The Port Warden shall enter in his books a statement showing manner of stowage and securing and issue a certificate accordingly.

Section 1 – Definitions

1.1 General Cargo Vessel

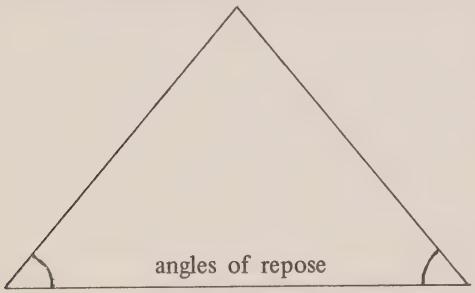
– a vessel of the single deck type, or a vessel having one or more 'tween decks, whose holds run without interruption from shell plating to shell plating or a vessel whose hold subdivision by longitudinal bulkheads is insufficient to effectively restrain the bulk cargo from shifts capable of imperilling stability and without special strengthening for heavy cargo.

1.2 Bulk Cargo

– a cargo consisting of solids in particle or granular form, with or without entrained moisture, generally homogeneous as to composition, and loaded directly into a vessel's cargo spaces without bagging or packaging. Grain cargoes are excluded from this Code because they are dealt with by Chapter VI of the International Convention on Safety of Life at Sea, 1960.

1.3 Angle of repose

– is the angle between a horizontal plane and the cone slope obtained when bulk cargo is emptied onto this plane.



A low angle of repose characterizes a bulk cargo which is particularly liable to dry surface movement aboard ship.

1.4 Concentrate

– is that material obtained when a natural ore has undergone some form of purification by physical separation of undesired ingredients; other materials having similar physical properties are included.

As contrasted to natural ores which include a considerable percentage of large particles and large lumps, concentrates ordinarily consist either exclusively of fine particles or relatively uniform pellets.

1.5 Moisture Content

– is that portion of a sample consisting of water, ice or other liquid* expressed as percentage of the total weight of that sample.

1.6 Flow Moisture Point

– is the moisture content at which a flow state develops.
(As in a sample under the test procedure described in Section 9).

1.7 Transportable Moisture Limit

– is the maximum moisture content of a concentrate deemed safe for carriage by sea in general cargo vessels which do not comply with the special provisions of section 6.2. It is determined as 90% of the flow moisture point.

1.8** Saturated

– a sample of bulk cargo is saturated when all the voids between the grains are filled with liquid when the sample is at rest.

1.9** Moisture Migration

– is the phenomenon associated with a transfer of contained moisture within the cargo. It may result in portions of the cargo reaching a flow state.

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* Procedures given in the Code apply only to the usual cases wherein the moisture consists almost entirely of water or ice.

** These terms are not used in the text of the Code and are included for information only.

2.1 Having regard to Regulation 19a of Chapter II of the International Convention on Safety of Life at Sea, 1960, a stability booklet should be provided aboard all cargo vessels which are subject to that Convention. Where bulk cargoes referred to in this Code, and requiring any of the loading and operational precautions specified therein, are to be carried, the information supplied to the shipmaster should include all necessary data relative thereto. Prior to sailing, the shipmaster should have calculations showing that the stability for the anticipated worst conditions during the voyage as well as that on departure will be satisfactory.

2.2 An excessively stiff ship may roll with such a violent motion that damage to the ship will result. However, a vessel with a relatively large GM (Metacentric height) is better able to resist the tendency to list if a shift of any type of cargo should occur. For this latter reason, no concern should be felt about operating a bulk laden vessel with a large GM where experience has demonstrated that the resulting motion is not too severe.

2.3 When loading a high density bulk cargo having a stowage factor of about 20 cubic feet per ton (0.56 cubic metres per metric ton) or lower, the loaded conditions are different from those found normally and it is important to pay particular attention to the distribution of weights so as to avoid excessive stresses. A general cargo vessel is normally constructed to carry cargoes of about 50-60 cubic feet per ton, (1.39-1.67 cubic metres per metric ton) when loaded to full bale cubic and deadweight capacity. Because of the high density of some bulk cargoes, it is possible, by unwise distribution of loading, to stress very highly either the structure locally under the load and/or the entire hull. It is not practicable to set out exact rules for the distribution of loading in all ships since the structural arrangements may vary greatly. It is therefore recommended that the shipmaster be provided with sufficiently comprehensive loading information to enable him to arrange the loading aboard his ship so as not to overstress the structure.

2.4 When such information is not available for high density bulk cargoes, the following precautions are given for guidance only:

(a) the general fore and aft distribution of cargo by weight should not differ appreciably from that found satisfactory for general cargoes, and

(b) the maximum number of tons of cargo loaded in any lower hold should not exceed:

where the measurements are in feet:

$$\frac{db\,(3L + B)}{165} \quad \text{long tons}$$

where the measurements are in metres:

$$\frac{db\,(3L + B)}{4.6} \quad \text{metric tons}$$

where d is the ship's summer load draft
b is the average breadth of the lower hold
L is the length of the lower hold
B is the ship's maximum moulded breadth

(c) where cargo is untrimmed or only partially trimmed the corresponding height of cargo pile peak above the hold floor should not exceed:

where the measurements are in feet:

$$\frac{d \text{ X stowage factor}}{19}$$

where the measurements are in metres:

$$1.89 \text{ X } d \text{ X stowage factor}$$

where the stowage factor is given in cubic feet per long ton for calculation in feet, or as cubic metres per metric ton for calculation in metres,

(d) if the cargo is trimmed entirely level the maximum number of tons of cargo loaded in any lower hold may be increased by 20 per cent over the amount calculated by the formula given in (b), subject however to full compliance with (a),

(e) because of the stiffening effect of a shaft tunnel on the ship's bottom, lower holds abaft the machinery space may be loaded somewhat more deeply than provided in (b), (c) and (d), up to about 10 per cent in excess, provided that such additional loading is consistent with (a).

2.5 Prior to, and during, loading of bulk cargoes all safety precautions required by the ordinary practice of seamen should be observed.

2.6 The shipmaster is advised that precautions should be taken to minimize the extent to which dust may come into contact with the moving parts of deck machinery.

2.7 Wherever possible, ventilation systems should be shut down or screened during loading or discharge, in order to minimize the entry of dust into the living quarters or other interior spaces of the ship.

2.8 Before loading, the holds should be inspected and thoroughly prepared for the particular bulk cargo which it is intended to load.

2.9 Attention is particularly drawn to bilge wells and strainer plates which should be prepared to facilitate drainage.

2.10 Before loading bulk cargoes, the shipmaster should ensure that bilge lines, sounding pipes and other service lines within the compartment are in good order. Because of the velocity at which some high density bulk cargoes are loaded into the hold, special care may be necessary to protect hold equipment and appurtenances from damage. For this reason it is also prudent to sound bilges after the completion of loading.

Section 3 – Bulk cargoes including ore and similar cargoes having an angle of repose greater than 35 degrees

3.1 High density cargo should be loaded entirely in the lower holds unless this results in the ship being too "stiff" or in the cargo weight on the bottom structure being excessive. When cargo is loaded only in lower holds, it should be trimmed sufficiently to cover all of the tank top out to the ship's side, and otherwise as necessary in order to reduce the pile peak height and equalize the weight distribution on the bottom structure.

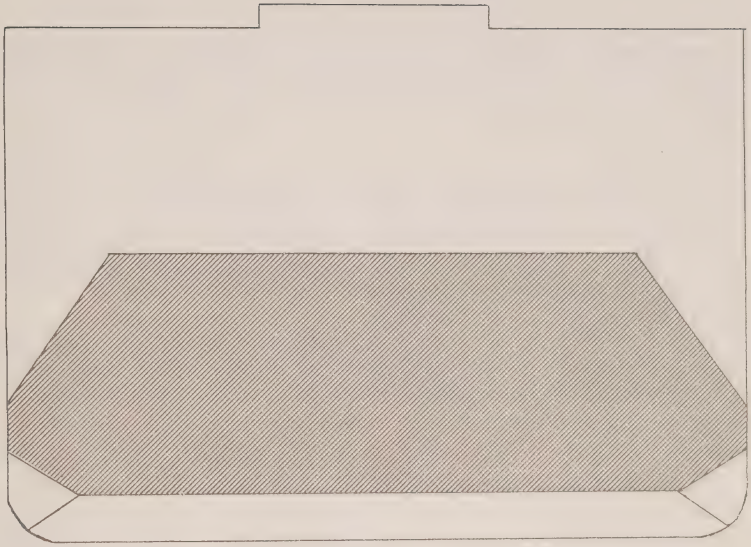
3.1.1 Such triming as is necessary may generally be accomplished by levelling within the hatch square, with the remaining cargo sloped approximately uniformly to the lower hold sides, and substantially so, to the end bulkheads. Provided that there is no conflict with the Load-Line Regulations, and if an excessive peak height does not result, cargo may extend up through the "tween-deck" hatchway which should then be left uncovered. In such case, the pile should be sufficiently clear of the hatchway edges so that any possible slide of the pile peak will remain in the hold.

3.2 When cargo is loaded in the 'tween-decks to reduce "stiffness" of the vessel or to minimize stresses in the bottom structure the following considerations should be noted.

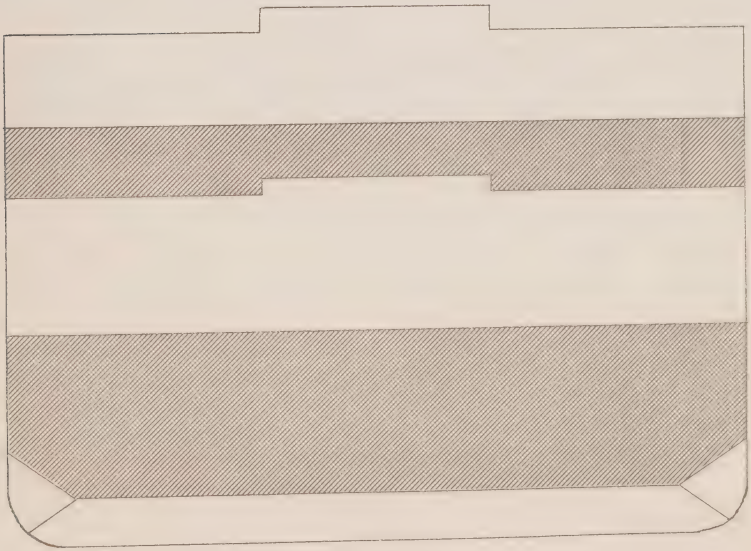
3.2.1 A relatively high GM (Metacentric height) is necessary when carrying high density bulk cargoes in order to reduce the heel which would result from a possible shift of cargo. The maximum GM (Metacentric height) which can be satisfactorily maintained will vary on different routes according to the prevailing weather conditions.

3.2.2 It is recommended that the total amount of high density bulk cargo carried in the 'tween-decks should be the least amount necessary to prevent the vessel from being unduly "stiff" and that due regard be given to the 'tween-deck weight-bearing capacity in pounds per square foot (kilogrammes per square metre).

3.2.3 Where it is necessary to load cargo in the 'tween-decks, the 'tween-deck hatch should be closed. The 'tween-deck cargo should be trimmed reasonably level and should either extend from side to side and bulkhead to bulkhead, or should be secured in bins. Because of the reduced stability when cargo is carried in the 'tween-decks it is also generally necessary that the cargo in the lower hold be trimmed to a greater extent than when cargo is carried only in the lower hold.



Section 3.1.1



Section 3.2.3

Section 4 – Bulk cargoes including ore and similar cargoes having an angle of repose equal to or less than 35 degrees

4.1 Such cargoes generally require to be trimmed, and spaces in which they are loaded should be filled as full as is practicable without resulting in an excessive cargo weight on the supporting bottom structure or deck.

4.2 Where it is necessary to load such cargoes in the 'tween-decks the 'tween-deck cargo should be trimmed reasonably level. Whenever the amount or location of cargo carried in 'tween-deck compartments is such that the possible heeling moment due to cargo shift may be excessive, adequate shifting boards, bins or other securing arrangements should be provided.

4.3 Whenever the nature, amount or location of cargo carried in a partly filled hold is such that the possible shifting of the cargo may result in excessive heeling moments, adequate shifting boards, bins or other securing arrangements should be provided.

4.4 Where dry cargoes which flow very freely like grain are to be carried, it is recommended that the provisions applicable to the stowage and carriage of grain be fully observed, however account should be taken of the relative cargo density in determining:

(a) the scantlings and securing arrangements of shifting boards and bin bulkheads;
(b) the stability effect of cargo free surfaces.

Section 5 – Concentrates and similar materials – Hazards

5.1 At a moisture content below the Transportable Moisture Limit, concentrates may be subject to the hazards of dry movement. The provisions of sections 2, 3 and 4 applicable to ores and similar bulk cargoes are also applicable to all concentrates and provide a means for the assessment of hazard from such movements and appropriate control measures.

5.2 However, there are additional hazards which apply to concentrates and while millions of tons of concentrates are moved by sea every year, in the majority of cases without hazard, there have been casualties where the cargo has shifted as a result of excessive moisture content.

5.3 The major purpose of the sections of this Code dealing with concentrates is to draw the attention of shipmasters and others to the latent risk of such cargo shift and to describe the precautions which are deemed necessary to minimize this risk.

5.4 This hazard is typical of concentrates and similar finely divided materials when shipped in a damp state. Such cargoes may appear to be in a relatively dry granular state when loaded, and yet contain sufficient moisture so as to become fluid under the stimulus of compaction and the vibration which occurs during a voyage.

5.5 In the resulting viscous fluid state, cargo may flow to one side of the ship with a roll one way but not completely return with a roll the other way. Thus, the vessel may progressively reach a dangerous heel.

5.6 Some concentrates such as those containing sulphides may be also subject to oxidization and spontaneous heating when carried at a low moisture content. It may therefore be desirable to carry such concentrates at as high a moisture content as is practicable without running the risk of becoming fluid and consequently shifting.

Section 6 – Concentrates and similar materials – Precautions

6.1 General cargo vessels.

6.1.1 General cargo vessels should only carry concentrates having a moisture content not in excess of the transportable moisture limit as defined in this Code.

6.1.2 Cargoes which contain liquids other than packaged canned goods or the like, should not be stowed in the same compartment above or adjacent to a consignment of concentrates.

6.1.3 Adequate and sufficient precautions to prevent liquids entering the hold in which concentrates are stowed should be maintained during the voyage.

6.1.4 Shipmasters are cautioned of the possible danger in using water to cool a concentrate shipment while the vessel is at sea since the admission of water in quantity may well bring the moisture content of the concentrates to a flow state. Water is most effectively applied in the form of a spray.

6.2 Specially fitted general cargo vessels.

6.2.1 General cargo vessels which have specially designed arrangements to restrain the cargo may carry concentrates having a moisture content in excess of the transportable moisture limit.

6.2.2 The design and positioning of such special arrangements must adequately provide for not only the restraint of the immense forces generated by the flow movement of high density bulk cargoes, but also the need to reduce to an acceptable safe level the potential heeling moments arising out of a cargo flow transversely across the cargo compartment.

6.2.3 It may also be necessary for elements of the ship's structure bounding such cargo to be strengthened.

6.2.4 The plan of special arrangements deemed necessary and details of the stability conditions on which the design has been based should have been approved by the administration of the country of the ship's registry. In such cases the vessel concerned should carry evidence of approval by its Administration.

6.3 Specially constructed bulk ore vessels.

6.3.1 Vessels which are specially constructed for the carriage of bulk ore cargoes and in which internal structural boundaries are placed so as to sufficiently limit a shift of cargo, may carry concentrates of a moisture content which exceeds the transportable moisture limit. The vessel concerned should carry evidence of approval by its Administration.

6.3.2 The Department of Transport is prepared to approve such vessels, on behalf of their Administration, if requested to do so by the appropriate Authority.

6.3.3 This category of vessel would normally include those vessels which are arranged so that the hold space is divided longitudinally into three separate compartments none of which exceeds 50% of the moulded breadth of the vessel. It would not include those bulk carriers fitted with top wing tanks alone.

6.3.4 Vessels which have the approval of their own Administration for the carriage of concentrates of a moisture content which exceeds the transportable moisture limit may, on submission of their approved plans, be authorized by the Department to load concentrates in Canadian ports without direct supervision as detailed in section 10.5 of this Code.

6.4 Submission of data

6.4.1 A submission made to the Administration for approval of such a vessel under 6.2 or 6.3 should include:

(i) Scaled longitudinal and transverse section drawings and relevant structural drawings.

(ii) Stability calculations, taking into account loading arrangements and possible shift of the cargo, showing the distribution of cargo and liquids in tanks, and of cargo which may become fluid.

(iii) Any other information which may assist in the assessment of the submission.

7.1 Sample for determination of transportable moisture limit

7.1.1 To determine a transportable moisture limit, representative samples should be taken from a concentrate intended for carriage by sea and tested by a competent laboratory.

7.1.2 Representative samples of the concentrate for laboratory testing should be taken from an ore concentrate production at reasonable intervals. A test should be made on current production at least semi-annually, and particularly when there is any change in processing of the concentrate which might affect its physical characteristics and the transportable moisture limit. A copy of the certificate from an independent laboratory shall be provided by the concentrate producer to the Department of Transport and, at the time of shipment, to the Port Warden at the loading port.

7.2 Samples for moisture content at time of loading

7.2.1 Representative samples of a concentrate cargo which is to be loaded should be taken directly from the stockpile at or nearest the shipping point before the vessel loads. These samples should immediately be analysed and a certificate of moisture content be made by a qualified chemist or laboratory.

7.2.2 When there has been substantial precipitation between the time of taking samples from a stockpile that is exposed to the weather and the time of intended loading of a cargo, further representative samples should be taken and analysed for moisture content before loading.

7.2.3 Where the stockpile is situated at a place remote from the berth and shipment is made from the stockpile by rail, road or barge for direct loading into the ship representative samples taken from the stockpile may be used if the cargo has not been exposed to rain or other wetting during transfer from stockpile to ship. During continuous or heavy rain, loading should be suspended and the hatches covered. Similarly a concentrate to be loaded from railway cars, trucks or barges should be adequately protected.

7.2.4 Where the cargo is known to have been wetted during transfer or is held in trucks, railcars, or barges for some time before loading, representative samples should be taken prior to loading from approximately one truck in every five or the equivalent, at the surface and at half depths.

7.3 Certificates

7.3.1 A certificate stating the transportable moisture limit and the certified moisture content should be provided at the loading point to the shipmaster and to the Port Warden.

7.3.2 Certificates stating the transportable moisture limit should contain or be accompanied by a statement by the shipper that the moisture content specified in the certificate of moisture content is, to the best of his knowledge and belief, the average moisture content of the cargo at the time the certificate is presented to the Master or government official responsible to authorize commencement of loading. When cargo is to be loaded into more than one compartment of a vessel, the certificate of moisture content should certify to the moisture content of each type of concentrate loaded into each compartment. However, if the moisture content is uniform throughout the stockpile, then one certificate of average moisture content for all compartments should be acceptable.

8.1 The recommended detailed test procedure given in section 9 provides for the laboratory determination of:

(a) The moisture content of a representative sample of concentrate about to be loaded.

(b) The flow moisture point and the transportable moisture limit of the concentrate.

8.2 At a place outside of Canada, if a suitable drying oven and scale are available on board ship, the moisture content of the cargo about to be loaded may also be determined in the specified manner but by shipboard test, if the circumstances are such that a laboratory test cannot be made of the cargo about to be loaded.

8.3 On shipboard a supplementary procedure for approximately determining the possibility of flow may be used. A sample check may be obtained by the following method:

Half fill a cylindrical can of approximately 20 fluid ounces with a sample of concentrate. Take the can in one hand and sharply bring it down to strike a hard surface such as a solid table from a height of 8 inches. Repeat the procedure 25 times at one or two second intervals. Examine the surface for free moisture or fluid conditions. If free moisture or a fluid condition appears, steps should be taken to have additional laboratory analysis of the concentrate conducted before it is accepted for loading.

9.1 Scope

The tests described below provide for determination of:

(a) The moisture content of a concentrate sample.
(b) The flow moisture point of the concentrate under vibratory conditions.
(c) The transportable moisture limit of the concentrate.

9.2 Apparatus

(a)[1] Standard Flow Table and Frame
(b)[1] Table Mounting
(c)[1] Mold
(d)[2] Tamper
(e)[3] Scales and Weights
(f) Glass graduate and pipette having capacities of 100 to 200 ml. and 10 ml. respectively.
(g) A 12-inch diameter, hemispherical mixing bowl, rubber gloves and drying pans.
(h) A drying oven with controlled temperature of approximately 100° to 110° C.

9.2.1 References

A detailed description of the apparatus is given in:

1. ASTM Designation C 230
2. ASTM Designation C 109 para 2(h)
3. ASTM Designation C 109 para 2(a) and (b).

Standards of the American Society for Testing and Materials to which reference is made in the test method are reprinted with the kind permission of the Society. (see Annex I)

9.3 Temperature and humidity

It is preferable to work in a room where the samples will be protected from excessive extremes in temperature, air currents and humidity variation. During the handling of the sample throughout the test period, all phases of the testing procedure should be rapidly accomplished to minimize moisture losses.

9.4 Procedure

Approximately 2,500 g. of the test material is selected. Of this amount one sample amounting to about 500 g. is immediately weighed and placed in the drying oven. The remainder of the material will receive repetitive additions of 10 ml. volume increments of water until the flow point has been determined, as follows:

(a) 10 ml. of water are evenly distributed over the surface of the material. The material is then worked with rubber-bloved fingers until the water is thoroughly mixed with the material.

(b) The mold is placed on the flow table and filled in three operations of loading and tamping, i.e., the first charge of material should, after very firm tamping, fill the mold to approximately one-third of its total height. The second charge, after tamping, should bring the level of the material to approximately two-thirds of its total capacity and the final charge, heaped loosely over the opening, will drop with tamping to just below the surface of the mold. Very firm, solid pressures should be exerted during all tamping operations.

(c) Immediately following the final tamping, the mold is tapped loose and the flow table is dropped through a height of ½ inch, at a rate of 25 times per minute.

(d) If a point beyond the resistance to shear has not been reached, i.e. the moisture content is less than the flow moisture point, it is usual for the material to crumble and bump off in fragments.

(e) Additional increments of 10 ml. of water followed by procedures (a) to (c) are repeated until the flow point has been passed, as indicated by a plastic deformation of the material.

(f) A small increment of dry material is added by thorough mixing and procedures (b) and (c) repeated.

(g) Procedure (f) is repeated until in two successive operations of the flow table, two samples are obtained; one exhibiting slight plastic deformation and the other remaining stable.

(h) The two molded samples are immediately weighed and placed in the oven to determine their respective moisture contents.

(i) Samples are to be dried at a temperature of 105°C, plus or minus 5° C, until successive weighings indicate constant weight.

9.5 Determinations

(a) Moisture Content:

Taking w_1 as the exact weight of a sample before drying and w_2 as the exact weight of the sample after drying to constant weight:

The moisture content m $\dfrac{(w_1 - w_2)}{w_1} \times 100$ (% by weight)

(b) Flow Moisture Point:

Taking A% as the moisture content of the sample just above the flow point and B% as the moisture content of the sample just below it:

The flow moisture point may be taken as

$\dfrac{(A + B)}{2}$ (% by weight).

(c) Transportable Moisture Limit:

The transportable moisture limit of the concentrate = 90% of (b).

10. *Port Warden*

10.1 The Port Warden shall be acquainted with the probable dates of shipment of concentrates from his port or district.

10.2 When it is proposed to make a shipment of concentrates the Port Warden will receive the certificate of flow moisture point and the certificate of moisture content from the producer and shipper.

10.3 If the certificate of moisture content shows that the concentrates shipment does not exceed the transportable moisture limit and if, on inspection, the cargo spaces wherein it is intended to load concentrates comply with the requirements of approved practice, the Port Warden will issue a certificate of readiness to load to the vessel.

10.4 After the concentrates shipment has been loaded the Port Warden will ensure that the cargo has been trimmed in accordance with Section 3 or 4, as appropriate. If he is then satisfied with the vessel's fitness to proceed to sea he will issue the requisite certificate.

10.5 In each case of a specially constructed vessel having been authorized by the Department to load concentrates the Port Warden will be required to be present during the first occasion of loading. If satisfied that the vessel can safely be loaded without direct supervision he may issue a certificate under Section 624 (4) of the Canada Shipping Act, approving stowage for further similar voyages from that port or district. The validity of this certificate will extend for a period of one year from the date of issue and during such time the Port Warden will not make a tariff charge for loading survey unless this survey is made. If the method or manner of loading is changed, or the vessel leaves the specific trade for which the certificate has been issued, then the certificate becomes invalid and loading surveys again become mandatory. (See Annex III)

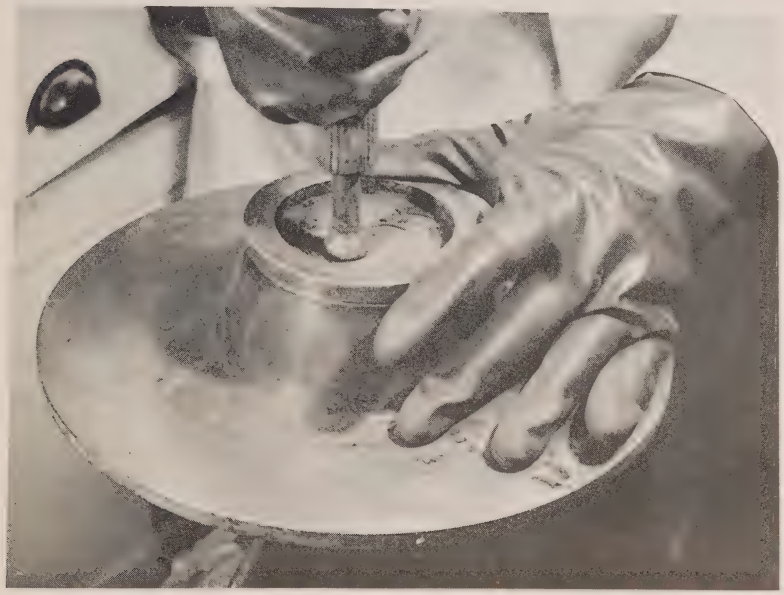
10.6 The preliminary and loading procedures detailed in Section 10.5 shall not be construed as to interfere in any way with the provisions of Section 626 of the Canada Shipping Act in regard to final certification of the vessel as being fit to proceed to sea after having loaded concentrates.

10.7 Where a vessel laden with concentrates arrives at a Canadian port the Port Warden will request the Master to complete the Departmental questionnaire respecting concentrates cargoes. The Port Warden will make a survey and report to the Department on the condition of every shipment of concentrates which is to be discharged at a port within his district. Reports and questionnaires will be referred to the Department without undue delay.

10.8 Where a vessel loads concentrates in a Canadian port the Port Warden will request the Master to complete a voyage questionnaire form and return it to the Regional Nautical Services Office from the discharge port. In addition the Port Warden will complete a duplicate form, as far as is possible at the loading port and return this directly to the Regional Nautical Services Office making a note on the form of the type of concentrate loaded, the origin of the cargo and the names of both porducer and shipper. (See Annex IV)

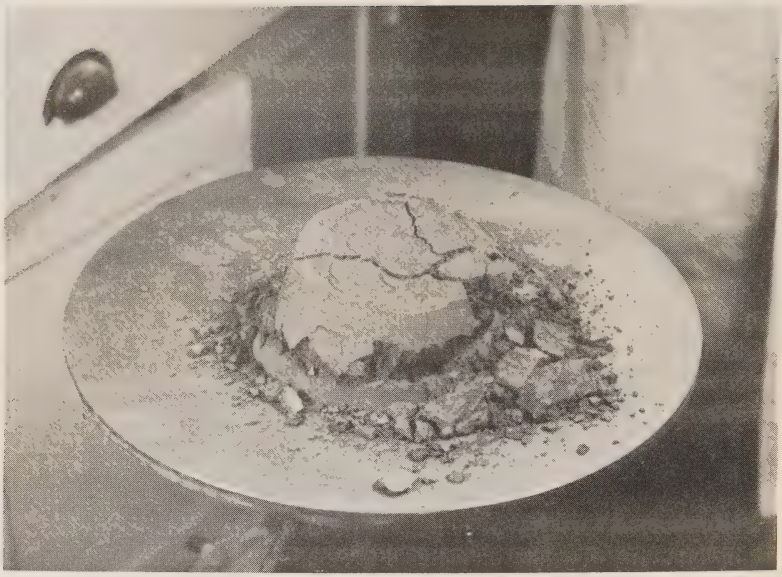
Narrative of the Flow Moisture Point Test

(1) A representative sample of the concentrate is selected and placed in a mixing bowl. The mould is put on the flow table and filled in three stages with a part of the selected material in the mixing bowl. The first charge, after very firm tamping, fills the mould to approximately one third of its depth; the second charge to about-thirds the depth, the third and final charge, after tamping, reaches to just below the top of the mould.



(2) The Code recommends that "very firm, solid pressures should be exerted during all tamping operations". As a concentrate is a very dense cargo, the lower levels of a stow will be under considerable pressure. It is, of course, impossible to simulate such pressures on the flow table but a considerable degree of compaction can be attained by tamping very firmly and applying solid pressures by hand. Light tamping is not considered sufficient due to the risk of the moulded material collapsing through lack of initial granular cohesion.

(3) The mould is tapped loose, leaving the sample in the shape of a truncated cone. The flow table is now vibrated vertically through a height of ½ inch at a rate of 25 times per minute. During the first few runs the material usually crumbles and bumps off in fragments; indicating that the flow state has not been reached.

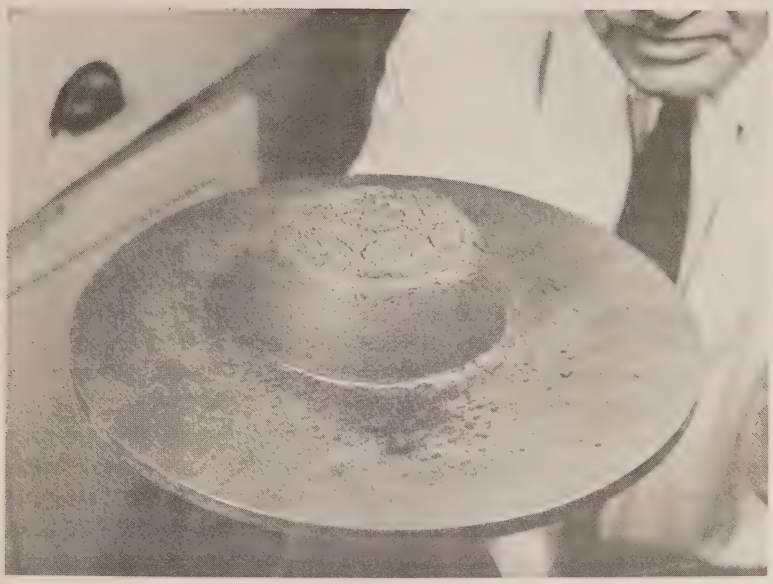


(4) The flow table is stopped and the material returned to the mixing bowl where 10 ml. of water is sprinkled over the surface and thoroughly mixed into the material with rubber-gloved fingers.

(5) The mould is again filled from the mixing bowl and the sample vibrated. The whole process is repeated, adding 10 ml. of water each time, until a flow state is reached. The action of the flow table causes the grains to rearrange themselves with possible compaction of the mass. As a result, the fixed volume of moisture contained in the material increases as a percentage of the whole. The moisture tends to pervade the mass, hastening the moment at which the resistance to shear disappears and causing a plastic deformation in the moulded sample.

(6) When the moisture content is sufficiently increased, a flow pattern will be developed at the initial drop of the table, although in the static condition the moulded material may be resistant to shear and not deform plastically. That is to say, the impact of the first drop initiates a re-arrangement of the grains (i.e. the flow pattern) which will subsequently lead to the noticable plastic deformation of the moulded material. It may be, however, that this phenomenon is not immediately apparent.

(7) At this stage, the moulded sides of the sample bow outwards, with possible cracking of the top surface, and the material continues to slump under the vibration of the table.



(8) Immediately the flow state has been reached about 500 grams of the moulded material is weighed and placed in a drying oven heated to 100° – 110° C. It is then dried for a period of 5 hours and is weighed again to determine the weight of moisture lost. The flow moisture point is calculated, in accordance with section 9.5 of the Code, as a percentage of the total weight of the sample before drying.

(9) Despite the use of relatively smaller increments of water, it is the practice to increase the accuracy of the determinations still further.

(10) Water increments of 10 ml. are added in the usual manner until flowing becomes apparent. This indicates that a point beyond the resistance to shear has been reached. The moisture content in the material is now reduced gradually (a practical way of doing this being to mix in some dry material) until only the slightest amount of slumping is observed. A very small quantity of dry material is now added and it is found that the moulded sample does not slump at all.

(11) In the first case the moisture content of the sample is just above the flow point whereas in the second case it is just below. Both samples are weighed and dried to determine their moisture contents; the flow moisture point being taken as the mean of the two values so obtained.

(12) The Code recommends that the samples should be dried for a period of 5 hours. It is clearly important that the samples should be dried to constant weight. In practice this is ascertained after a suitable drying period, by weighing the sample successively with an interval of several hours elapsing. If the weight remains constant, drying has been completed; whereas if the weight is still decreasing, drying is continued.

(13) The length of the drying period depends upon many variables such as the disposition of the material in the oven, the type of container used, the particle size, the rate of heat transfer, etc. It may be that a period of 5 hours is ample for one concentrate sample whereas it is not sufficient for another.

AMERICAN SOCIETY FOR TESTING AND MATERIALS
1916 Race St., Philadelphia 3, Pa.

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APPROVED AS
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Tentative Specifications for

FLOW TABLE FOR USE IN TESTS OF HYDRAULIC CEMENT[1]

ASTM Designation: C 230 – 61 T

ISSUED, 1949; REVISED, 1952, 1955, 1957, 1961.[2]

These Tentative Specifications have been approved by the sponsoring committee and accepted by the Society in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia 3, Pa.

Scope

1. These specifications cover requirements for the flow table and accessory apparatus used in making flow tests for consistency of mortars in tests of hydraulic cement.

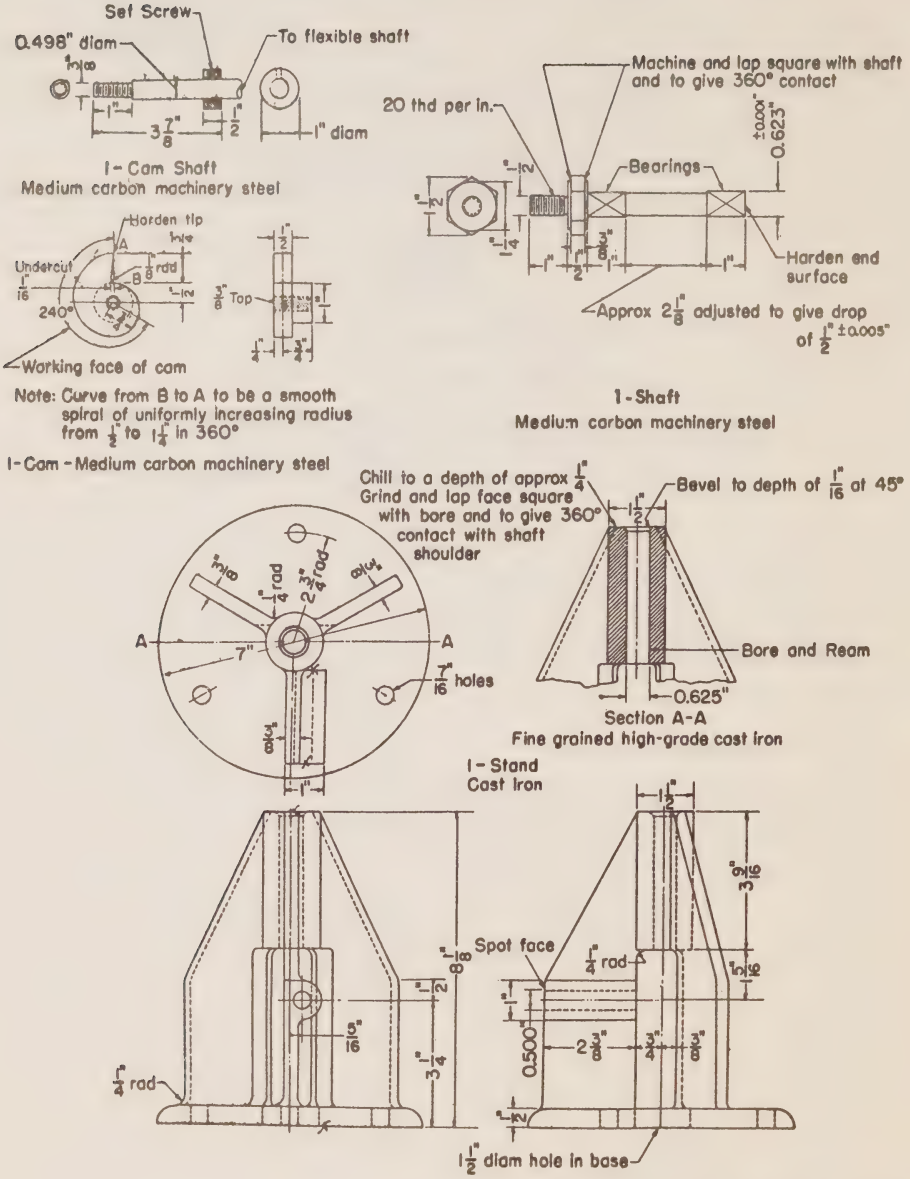
Flow Table and Frame

2. (*a*) The flow table apparatus shall be constructed in accordance with Fig. 1. The apparatus shall consist of an integrally cast rigid iron frame and a circular rigid table top 10 ± 0.1 in. in diameter, with a shaft attached perpendicular to the table top by means of a screw thread. The table top, to which the shaft with its integral contact shoulder is attached, shall be mounted on a frame in such a manner that it can be raised and dropped vertically through the specified height with a tolerance in height of ±0.005 in. for new tables and ±0.015 in. for tables in use, by means of a rotated cam. The table top shall have a fine machined plane surface, free of blowholes and surface defects, and shall be scribed as shown in Fig. 1. The table top shall be of cast brass or bronze having a Rockwell hardness number not less than B 25 with an edge thickness of 0.3 in., and shall have six integral radial stiffening ribs. The table top and attached shaft shall weigh 9 ± 0.1 lb and the weight shall be symmetrical around the center of the shaft.

(*b*) The cam and vertical shaft shall be of medium carbon machinery steel, hardened where indicated in Fig. 1. The shaft shall be straight and the difference between the diameter of the shaft and the diameter of the bore of the frame shall be not less than 0.002 in. and not more than 0.003 in. for new tables and shall be maintained at from 0.002 to 0.010 in. for tables in use. The end of the shaft shall not fall upon the cam at the end of the drop, but shall make contact with the cam not less than 120 deg from the point of drop. The face of the cam shall be a smooth spiraled curve of uniformly increasing radius from ½ to 1½ in. in 360 deg and there shall be no appreciable jar as the shaft comes into contact with the cam. The cam shall be so lo-

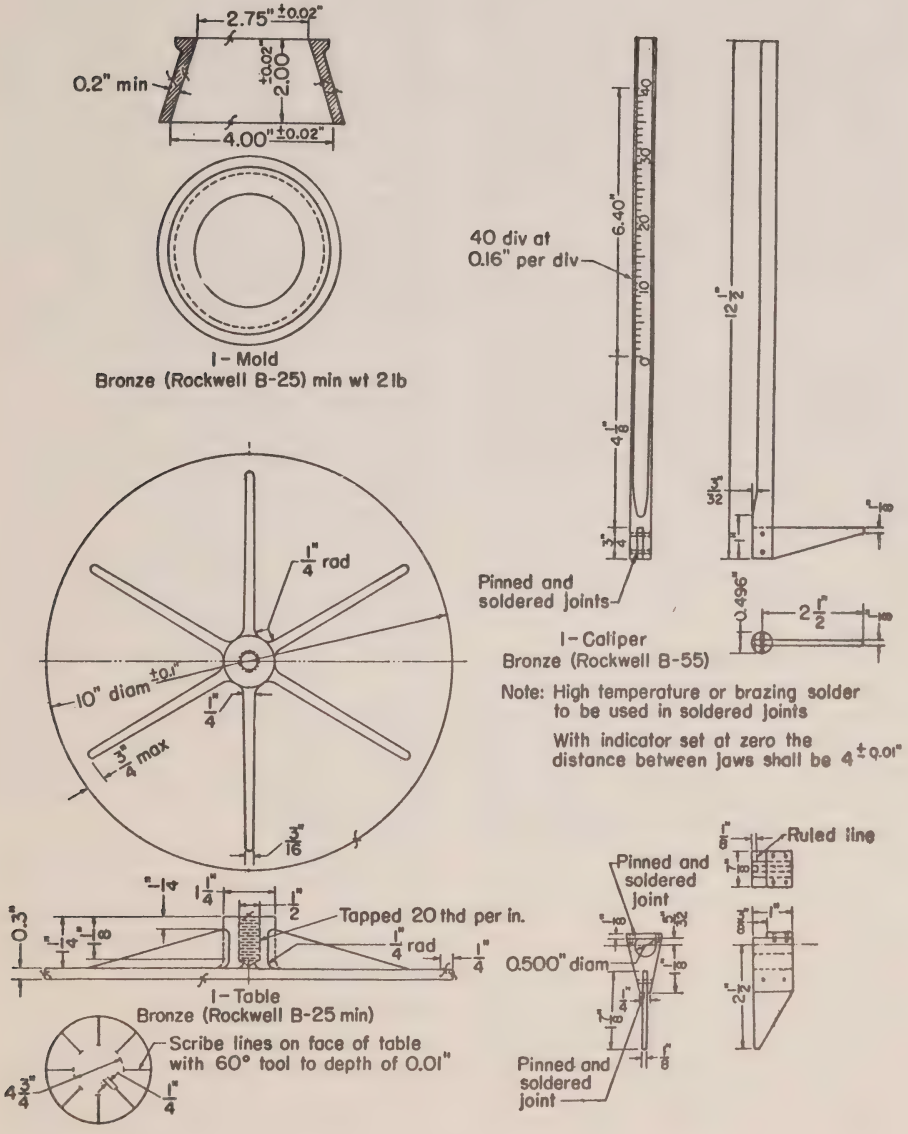
[1] Under the standardization procedure of the Society, these specifications are under the jurisdiction of the ASTM Committee C-1 on Cement.

[2] Latest revision accepted by the Society at the Annual Meeting, June, 1961.



NOTE.—The weight of the table top and

FIG. 1.—Flow Table and



shaft assembly shall be 9 ± 0.1 lb.

Accessory Apparatus.

cated and the contact faces of the cam and shaft shall be such that the table does not rotate more than one revolution in 25 drops. The surfaces of the frame and of the table which come into contact at the end of the drop shall be maintained smooth, plane, and horizontal and parallel with the upper surface of the table and shall make continuous contact over a full 360 deg.

(*c*) The supporting frame of the flow table shall be integrally cast of fine-grained, high-grade cast iron. The frame casting shall have three integral stiffening ribs extending the full height of the frame and located 120 deg apart. The top of the frame shall be chilled to a depth of approximately ¼ in. and the face ground and lapped square with the bore and to give 360-deg contact with the shaft shoulder. The underside of the base of the frame shall be ground to secure a complete contact with the steel plate beneath.

(*d*) The flow table shall be driven by a motor (Note), connected to cam shaft through an enclosed worm gear speed reducer and flexible coupling. The speed of the cam shaft shall be approximately 100 rpm. The motor drive mechanism shall not be fastened or mounted on the table base plate or frame.

NOTE.—A ⅓₀ hp motor has been found adequate.

(*e*) The performance of a flow table shall be considered satisfactory if, in calibration tests, the table gives a flow value that does not differ by more than 5 percentage points from flow values obtained with a suitable calibration material.[3]

Flow Table Mounting

3. (*a*) The flow table frame shall be tightly bolted to a cast iron or steel plate at least 1 in. thick and 10 in. square. The top surface of this plate shall be machined to a smooth plane surface. The plate shall be anchored to the top of a concrete pedestal by four ½-in. bolts that pass through the plate and are imbedded at least 6 in in the pedestal. The pedestal shall be cast inverted on the base plate. A positive contact between the base plate and the pedestal shall be obtained at all points. No nuts or other such levelling devices shall be used between the plate and the pedestal Levelling shall be effected by suitable means under the base of the pedestal.

The pedestal shall be 10 to 11 in. square at the top, and 15 to 16 in. square at the bottom, 25 to 30 in. in height, and shall be of monolithic construction, cast from concrete weighing at least 140 lb per cu ft. A stable gasket cork pad, ½ in. thick and approximately 4 in. square, shall be inserted under each corner of the pedestal. The flow table shall be checked frequently for levelness of table top, stability of pedestal, and tightness of bolts and nuts in table base and pedestal plate. (A torque of 20 ft-lb is recommended when tightening those fastenings.)

(*b*) The table top, after the frame has been mounted on the pedestal, shall be level along two diameters at right angles to each other, in both the raised and lowered positions.

Flow Table Lubrication

4. The vertical shaft of the table shall be kept clean and shall be lightly lubricated with a light oil (SAE-10). Oil shall not be present between the contact faces of the table top and the supporting frame. Oil on the cam face will lessen wear and promote smoothness of operation. The table should be raised and permitted to drop a dozen or more times just prior to use if it has not been operated for some time.

[3] Such a material may be obtained from the Cement Reference Laboratory at the National Bureau of Standards, Washington 25, D. C.

Mold and Caliper

5. (*a*) The mold for casting the flow specimen shall be of cast bronze or brass, constructed as shown in Fig. 1. The Rockwell hardness number of the metal shall be not less than B 25 and the mold shall weigh not less than 2 lb. The surfaces of the base and top shall be parallel and at right angles to the vertical axis of the cone. The mold shall have a minimum wall thickness of 0.2 in. The outside of the top edge of the mold shall be shaped so as to provide an integral collar for convenient lifting of the mold. All surfaces shall be machined to a smooth finish. A circular shield approximately 10 in. in diameter, with a center opening approximately 4 in. in diameter, made of nonabsorbing material not attacked by the cement, shall be used with the flow mold to prevent mortar from spilling on the table top.

(*b*) A caliper, conforming to the design and dimensions shown in Fig. 1 (Note), shall be provided for measuring the diameter of the mortar after it has been spread by the operation of the table. The scale shall be machine divided and the construction and accuracy of the instrument shall be such that the distance between the jaws shall be 4 ± 0.01 in. when the indicator is set at zero.

NOTE.—The caliper shown in Fig. 1 is graduated to indicate one fourth of actual flow, so that the readings of four measurements may be added to give the flow value without the necessity of calculating the average of four individual measurements.

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Standard Method of Test for

COMPRESSIVE STRENGTH OF HYDRAULIC CEMENT MORTARS (USING 2-IN. CUBE SPECIMENS)[1]

ASTM Designation: C 109 – 58

ADOPTED, 1956; REVISED, 1958.[2]

This Standard of the American Society for Testing Materials is issued under the fixed designation C 109; the final number indicates the year of original adoption as standard or, in the case of revision, the year of last revision.

Scope

1. This method of test is intended for determining the compressive strength of hydraulic cement mortars, using 2-in. cube specimens.

NOTE.—The Tentative Method of Test for Compressive Strength of Hydraulic Cement Mortars (Using Portions of Prisms Broken in Flexure) (ASTM Designation: C 349)[3] provides an alternative procedure for this determination.

Apparatus

2. (*a*) *Scales.*—The scales used in weighing materials for mortar mixes shall conform to the following requirements: On scales in use the permissible variation at a load of 2000 g shall be ±2.0 g. The permissible variation on new scales shall be one half of this value. The sensibility reciprocal[4] shall be not greater than twice the permissible variation.

(*b*) *Weights.*—The permissible variations on weights in use in weighing materials for mortar mixes shall be as prescribed in Table I. The permissible variations on new weights shall be one half of the values in Table I.

(*c*) *Sieves.*—Square-hole, woven wire cloth No. 100 (149-micron), No. 50 (297-micron), No. 30 (590-micron) and No. 16 (1190-micron) sieves conforming to the Specifications for Sieves for Testing Purposes (ASTM Designation: E 11)[3] shall be used.

(*d*) *Glass Graduates.*—Glass graduates

[1] Under the standardization procedure of the Society, this method is under the jurisdiction of the ASTM Committee C-1 on Cement.

[2] Prior to adoption as standard this method was published as tentative from 1934 to 1944, being revised in 1937, 1943, and 1944. It was published as standard from 1944 to 1954, being revised in 1947, 1949, 1950, and 1952. It was revised and reverted to tentative in 1954 and published as tentative from 1954 to 1956.

[3] Appears in this publication, see Contents in Numeric Sequence of ASTM Designations at front of book.

[4] Generally defined, the sensibility reciprocal is the change in load required to change the position of rest of the indicating element or elements of a non-automatic-indicating scale a definite amount at any load. For more complete definition, see "Specifications, Tolerances, and Regulations for Commercial Weighing and Measuring Devices" *Handbook H44*, National Bureau of Standards, September, 1949, pp. 92 and 93.

of suitable capacities (preferably large enough to measure the mixing water in a single operation) shall be made to deliver the indicated volume at 20 C (68 F). The permissible variation shall be ±2 ml. These graduates shall be subdivided to at least 5 ml, except that the graduation lines may be omitted for the lowest 10 ml for a 250-ml graduate and for the lowest 25 ml for a 500-ml graduate. The main graduation lines shall be circles and shall be numbered. The least graduations shall extend at least one seventh of the way around, and intermediate graduations shall extend at least one fifth of the way around.

TABLE I.—PERMISSIBLE VARIATIONS ON WEIGHTS.

Weight, g	Permissible Variations on Weights in Use, plus or minus, g
1000	0.50
900	0.45
750	0.40
500	0.35
300	0.30
250	0.25
200	0.20
100	0.15
50	0.10
20	0.05
10	0.04
5	0.03
2	0.02
1	0.01

(*e*) *Specimen Molds.*—Molds for the 2-in. cube test specimens shall be tight fitting. The molds shall have not more than three cube compartments and shall be separable into not more than two parts. The parts of the molds when assembled shall be positively held together. The molds shall be made of hard metal not attacked by the cement mortar. For new molds the Rockwell hardness number of the metal shall be not less than B 55. The sides of the molds shall be sufficiently rigid to prevent spreading or warping. The interior faces of the molds shall be plane surfaces with a permissible variation of 0.001 in. for new molds and 0.002 in. for molds in use. The distances between opposite faces shall be 2 ± 0.005 in. for new molds, and 2 ± 0.02 in. for molds in use. The height of the molds, measured separately for each cube compartment, shall be 2 in. with permissible variations of +0.01 in. and −0.005 in. for new molds, and +0.01 in. and −0.015 in. for molds in use. The angle between adjacent interior faces, and between interior faces and top and bottom planes of the mold, shall be 90 ± 0.5 deg measured at points slightly removed from the intersection of the faces.

(*f*) *Mixer, Bowl, and Paddle.*—The mixer shall be an electrically driven mechanical mixer of the type equipped with paddle and mixing bowl, as specified in Section 2(*a*), (*b*), and (*c*) of the Tentative Method for Mechanical Mixing of Hydraulic Cement Mortars of Plastic Consistency (ASTM Designation: C 305).[3]

(*g*) *Flow Table and Flow Mold.*—The flow table and flow mold shall conform to the requirements of the Tentative Specifications for Flow Table for Use in Tests of Hydraulic Cement (ASTM Designation: C 230).[3]

(*h*) *Tamper.*—The tamper shall be made of a nonabsorptive, nonabrasive, nonbrittle material such as a rubber compound having a Shore A durometer hardness of 80 ± 10 or seasoned oak wood rendered nonabsorptive by immersion for 15 min in paraffin at approximately 200 C (392 F), and shall have a cross-section of ½ by 1 in. and a convenient length (5 or 6 in.). The tamping face shall be flat and at right angles to the length of the tamper.

(*i*) *Trowel.*—The trowel shall have a steel blade 4 to 6 in. in length, with straight edges.

(*j*) *Testing Machine.*—The testing machine may be either the hydraulic or the screw type, with sufficient opening between the upper bearing surface and the lower bearing surface of the machine to permit the use of verifying apparatus.

The load applied to the test specimen shall be indicated with an accuracy of ±1.0 per cent. The upper bearing shall be a spherically seated, hardened metal block firmly attached at the center of the upper head of the machine. The center of the sphere shall lie at the center of the surface of the block in contact with the specimen. The block shall be closely held in its spherical seat, but shall be free to turn in any direction. The diagonal or diameter (Note) of the bearing surface shall be only slightly greater than the diagonal of the face of the 2-in. cube in order to facilitate accurate centering of the specimen. A hardened metal bearing block shall be used beneath the specimen to minimize wear of the lower platen of the machine. The bearing block surfaces intended for contact with the specimen shall have a Rockwell hardness number not less than C 60. These surfaces shall not depart from plane surfaces by more than 0.0005 in. when the blocks are new and shall be maintained within a permissible variation of 0.001 in.

NOTE.—A diameter of 3½ in., which is large enough for testing 3 by 6-in. cylinders, is satisfactory, provided that the lower bearing block has a diameter slightly greater than the diagonal of the face of the 2-in. cube but not more than 2.9 in., and is centered with respect to the upper bearing block and held in position by suitable means.

Temperature and Humidity

3. The temperature of the air in the vicinity of the mixing slab, the dry materials, molds, base plates, and mixing bowl, shall be maintained between 20 and 27.5 C (68 and 81.5 F). The temperature of the mixing water, moist closet or moist room, and water in the storage tank shall not vary from 23 C (73.4 F) by more than ±1.7 C (3 F).

(*b*) The relative humidity of the laboratory shall be not less than 50 percent. The moist closet or moist room shall be so constructed as to provide storage facilities for test specimens at a relative humidity of not less than 90 per cent.

Graded Standard Sand

4. The sand (Note) used for making test specimens shall be natural silica sand from Ottawa, Ill., graded as follows:

Sieve	Percentage Retained
No. 100 (149-micron)	98 ± 2
No. 50 (297-micron)	72 ± 5
No. 30 (590-micron)	2 ± 2
No. 16 (1190-micron)	none

NOTE: *Segregation of Graded Sand.*—The graded standard sand should be handled in such a manner as to prevent segregation, since variations in the grading of the sand cause variations in the consistency of the mortar. In emptying sacks of sand into bins or in scooping sand out of bins or sacks, care should be exercised to prevent the formation of mounds of sand or craters in the sand, down the slopes of which the coarser particles will roll. Bins should be of sufficient size to permit these precautions. Devices for drawing the sand from bins by gravity should not be used.

Sieve Analysis of Sand

5. (*a*) For checking the grading of the sand, make a sieving test of the sand on each of the four sieves specified in Section 2(*c*). Quarter samples of sand for the sieve tests from a sample of about 700 g obtained by the method of quartering the contents of a full sack (100 lb) which have been thoroughly mixed and the pile flattened or spread out to minimize segregation during quartering.

(*b*) Make the test on each sieve with approximately 100 g of sand. Do not attempt the selection of an exact predetermined weight. Perform the sieving operations in the manner specified for sieving cement in the Standard Method of Test for Fineness of Hydraulic Cement by the No. 200 Sieve (ASTM Designation: C 184),[3] except to continue the sieving until not more than 0.5 g passes through in 1 min of continuous sieving. Express the weight of the resi-

due on the sieve as a percentage of the weight of the original sample. Mechanical sieving devices may be used, but the sand shall not be rejected if it meets the requirements when tested by the hand method described in Method C 184.

Number of Specimens

6. Three or more specimens shall be made for each period of test specified.

Preparing Specimen Molds

7. Thinly cover the interior faces of the specimen molds with mineral oil or light cup grease. Thinly cover the contact surfaces of the halves of each mold with a heavy mineral oil or light cup grease such as petrolatum. After assembling the molds, remove excess oil or grease from the interior faces and the top and bottom surfaces of each mold. Set the molds on plane, nonabsorptive base plates that have been thinly coated with mineral oil, petrolatum, or light cup grease. Apply a mixture of 3 parts of paraffin to 5 parts of rosin by weight, heated between 110 and 120 C (230 and 248 F), at the outside contact lines of the molds and base plates so that watertight joints are effected between the molds and the base plates (Note).

NOTE: *Watertight Molds.*—The mixture of paraffin and rosin specified for sealing the joints between molds and base plates may be found difficult to remove when molds are being cleaned. Use of straight paraffin is permissible if a watertight joint is secured, but due to the low strength of paraffin it should be used only when the mold is not held to the base plate by the paraffin alone. A watertight joint may be secured with paraffin alone by slightly warming the mold and base plate before brushing the joint. Molds so treated should be allowed to return to the specified temperature before use.

Proportioning, Consistency, and Mixing of Mortars

8. (*a*) The proportions of dry materials of the standard mortar shall be one part of cement to 2.75 parts of graded standard sand by weight. The quantities of dry materials to be mixed at one time in the batch of mortar for making six test specimens shall be 500 g of cement and 1375 g of graded standard sand. The quantities of dry materials to be mixed at one time in the batch of mortar for nine test specimens shall be 740 g of cement and 2035 g of graded standard sand. The amount of mixing water, measured in milliliters, shall be such as to produce a flow of between 100 and 115 as determined in accordance with Section 9 and shall be expressed as a percentage by weight of the cement (Note).

NOTE.—As a guide for the initial trial mortar, the percentage of water by weight of the cement to produce the specified flow will be about 47 per cent for portland cement containing air-entraining material and about 49 per cent for portland cement not containing air-entraining material.

(*b*) Mixing shall be done mechanically in accordance with the procedure given in Section 5 of Method C 305. Upon completion of mixing, the mixing paddle shall be shaken to remove excess mortar into the mixing bowl.

Determination of Flow

9. Carefully wipe the flow-table top clean and dry and place the flow mold at the center. Place a layer of mortar about 1 in. in thickness in the mold and tamp 20 times with the tamper. The tamping pressure shall be just sufficient to insure uniform filling of the mold. Then fill the mold with mortar and tamp as specified for the first layer. Cut off the mortar to a plane surface, flush with the top of the mold, by drawing the straight edge of a trowel (held nearly perpendicular to the mold) with a sawing motion across the top of the mold. Wipe the table top clean and dry, being especially careful to remove any water from around the edge of the flow mold. Lift the mold away from the mortar 1 min after completing the mixing opera-

tion. Immediately, drop the table through a height of ½ in. 25 times in 15 sec. The flow is the resulting increase in average base diameter of the mortar mass, measured on at least four diameters at approximately equi-spaced intervals, expressed as a percentage of the original base diameter. Make trial mortars with varying percentages of water until the specified flow is obtained. Make each trial with fresh mortar.

Molding Test Specimens

10. Immediately following completion of the flow test, return the mortar from the flow mold to the mixing bowl. Quickly scrape down into the batch the mortar that may have collected on the side of the bowl and give the entire batch a 15-sec mixing at medium speed. Start molding the specimens within a total elapsed time of not more than 2 min and 15 sec after completion of the original mixing of the mortar batch. Place a layer of mortar about 1 in. in thickness in all of the cube compartments. Tamp the mortar in each cube compartment (Section 2 (*h*)) 32 times in about 10 sec in four rounds, each round to be at right angles to the other and consisting of eight adjoining strokes over the surface of the specimen, as illustrated in Fig. 1. The tamping pressure shall be just sufficient to insure uniform filling of the molds. The four rounds of tamping (32 strokes) of the mortar shall be completed in one cube before going to the next. When the tamping of the first layer in all of the cube compartments is completed, fill the compartments with the remaining mortar and then tamp as specified for the first layer. During tamping of the second layer bring in the mortar forced out onto the tops of the molds after each round of tamping by means of the gloved fingers and the tamper upon completion of each round and before starting the next round of tamping. On completion of the tamping, the tops of all cubes should extend slightly above the tops of the molds. Bring in the mortar that has been forced out onto the tops of the molds with a trowel and smooth off the cubes by drawing the flat side of the trowel (with the leading edge slightly raised) once across the top of each cube at right angles to the length of the mold. Then, for the purpose of levelling the mortar and making the mortar that protrudes above the top of the mold of more uniform thickness, draw the flat side of the trowel (with the leading edge slightly raised) lightly once along the length of the mold. Cut off the mortar to a plane surface flush with the top of the mold by drawing the straight edge of the trowel (held nearly perpendicular to the mold) with a sawing motion over the length of the mold.

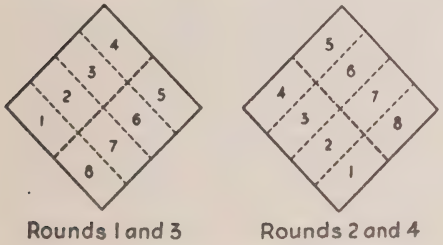

FIG. 1.—Order of Tamping in Molding of Test Specimens.

NOTE.—When a duplicate batch is to be made immediately for additional specimens, the flow test may be omitted and the mortar allowed to stand in the mixing bowl for 90 sec and then remixed for 15 sec at medium speed before starting the molding of the specimens.

Storage of Test Specimens

11. Immediately upon completion of molding, place the test specimens in the moist closet or moist room. Keep all test specimens, immediately after molding, in the molds on the base plates in the moist closet or moist room from 20 to

24 hr with their upper surfaces exposed to the moist air but protected from dripping water. If the specimens are removed from the molds before 24 hr, keep them on the shelves of the moist closet or moist room until they are 24 hr old, and then immerse the specimens, except those for the 24-hr test, in clean water in storage tanks constructed of noncorroding materials. Keep the storage water clean by frequent changing.

Procedure

12. (*a*) Test the specimens immediately after their removal from the moist closet in the case of 24-hr specimens, and from storage water in the case of all other specimens. If more than one specimen at a time is removed from the moist closet for the 24-hr tests, keep these specimens covered with a damp cloth until time of testing. If more than one specimen at a time is removed from the storage water for testing, keep these specimens in water at a temperature of 23 ± 1.7 C (73.4 ± 3 F) and of sufficient depth to completely immerse each specimen until time of testing.

(*b*) Wipe each specimen to a surface-dry condition, and remove any loose sand grains or incrustations from the faces that will be in contact with the bearing blocks of the testing machine. Check these faces by applying a straightedge (Note). If there is appreciable curvature, grind the face or faces to plane surfaces or discard the specimen.

NOTE: *Specimen Faces.*—Results much lower than the true strength will be obtained by loading faces of the cube specimen that are not truly plane surfaces. Therefore, it is essential that specimen molds be kept scrupulously clean, as otherwise, large irregularities in the surfaces will occur. Instruments for cleaning molds should always be softer than the metal in the molds to prevent wear. In case grinding specimen faces is necessary, it can be accomplished best by rubbing the specimen on a sheet of fine emery paper or cloth glued to a plane surface, using only a moderate pressure. Such grinding is tedious for more than a few thousandths of an inch; where more than this is found necessary, it is recommended that the specimen be discarded.

(*c*) Apply the load to specimen faces that were in contact with the true plane surfaces of the mold. Carefully place the specimen in the testing machine below the center of the upper bearing block. Use no cushioning or bedding materials. An initial loading up to one half of the expected maximum load for specimens having expected maximum loads of more than 3000 lb may be applied at any convenient rate. Apply no initial loading to specimens having expected maximum loads of less than 3000 lb. Adjust the rate of load application so that the remainder of the load (or the entire load in the case of expected maximum loads of less than 3000 lb) is applied, without interruption, to failure at such a rate that the maximum load will be reached in not less than 20 nor more than 80 sec. Make no adjustment in the controls of the testing machine while a specimen is yielding rapidly immediately before failure.

Calculation

13. Record the total maximum load indicated by the testing machine, and calculate the compressive strength in pounds per square inch. If the cross-sectional area of a specimen varies more than 0.06 sq in. from 4.00 sq in., use the actual area for the calculation of the compressive strength. The compressive strength of all acceptable test specimens (see Section 14) made from the same sample and tested at the same period shall be averaged and reported to the nearest 10 psi.

Faulty Specimens and Retests

14. In determining the compressive strength, do not consider specimens that

are manifestly faulty, or that give strengths differing by more than 10 per cent from the average value of all test specimens made from the same sample and tested at the same period (Note). After discarding specimens or strength values, if less than two strength values are left for determining the compressive strength at any given period, make a retest.

NOTE.—Reliable strength results depend upon careful observance of all of the specified requirements and procedures. Erratic results at a given test period indicate that some of the requirements and procedures have not been carefully observed; for example, those covering the testing of the specimens as prescribed in Section 12 (*b*) and (*c*). Improper centering of specimens resulting in oblique fractures or lateral movement of one of the heads of the testing machine during loading will often cause lower strength results. A specimen so broken shall be considered as "manifestly faulty" if its strength differs by more than 10 per cent from the average of all test specimens made from the same sample and tested at the same period.

[For additional useful information on details of cement test methods, reference may be made to the "Manual of Cement Testing"; see the compilation of "ASTM Standards on Cement," latest edition.]

CANADA

DEPARTMENT OF TRANSPORT

MARINE REGULATIONS BRANCH
NAUTICAL AND PILOTAGE DIVISION

SPECIALLY BUILT SHIP APPROVED FOR THE CARRIAGE OF CONCENTRATES FROM CANADIAN PORTS.

Plans for ss/mv " " having been examined, the Department of Transport approves the carriage of concentrates with a moisture content exceeding the transportable moisture limit without additional precaution against shifting of the cargo.

_____ _____
Date Chief, Nautical & Pilotage Division

I, the undersigned Port Warden, certify that the loading and stowage proposed for this vessel complies with Canadian approved practice. This certificate is valid for a period not exceeding 12 months from_____ when the above vessel loads_____ concentrates at the port or district of_____.

_____ _____
Date Port Warden

DEPARTMENT OF TRANSPORT
MARINE REGULATIONS BRANCH

MASTER'S REPORT OF BEHAVIOUR OF CONCENTRATES

THE DEPARTMENT OF TRANSPORT WISHES TO LEARN AS MUCH AS POSSIBLE ABOUT THE BEHAVIOUR OF CONCENTRATES CARRIED BY SEA. THE MASTER IS REQUESTED TO COMPLETE THIS FORM AS FULLY AS POSSIBLE AND TO RETURN IT TO:

AN INTERNATIONAL REPLY COUPON MAY BE USED TO DEFRAY POSTAL EXPENSES AND IS SUPPLIED WITH THIS FORM. WHERE A VESSEL ARRIVES IN CANADA WITH A CARGO OF CONCENTRATES THIS FORM, WHEN COMPLETED, MAY BE HANDED TO THE PORT WARDEN AT THE DISCHARGE PORT.

NAME OF VESSEL	PORT OF REGISTRY	LOADING PORT	DISCHARGING PORT

IS VESSEL SPECIALLY BUILT? ☐ YES ☐ NO	WITH APPROVED PLAN? ☐ YES ☐ NO	NAME OF ADMINISTRATION WHICH GAVE APPROVAL

TYPE OF CONCENTRATES	QUANTITY (LONG TONS)	FLOW MOISTURE POINT	MOISTURE CONTENT

APPEARANCE OF CONCENTRATES WHEN LOADED	APPEARANCE OF CONCENTRATES WHEN DISCHARGED
☐ LUMPY ☐ FINE ☐ HARD ☐ SOFT ☐ SPONGY ☐ CRUMBLY ☐ WET ☐ DRY	TOP LAYER ☐ SOFT ☐ HARD ☐ WET ☐ DRY MIDDLE LAYER ☐ SOFT ☐ HARD ☐ WET ☐ DRY BOTTOM LAYER ☐ SOFT ☐ HARD ☐ WET ☐ DRY

DID CONCENTRATES SHIFT? ☐ YES ☐ NO	DID WATER COME TO SURFACE? ☐ YES ☐ NO	DID SURFACE BECOME SOFT? ☐ YES ☐ NO	TEMPERATURE OF CONCENTRATES WHEN LOADED

DID CONTRATES HEAT? ☐ YES ☐ NO	TO WHAT TEMPERATURE DID CONCENTRATES HEAT?	DID CONCENTRATES ☐ BURN ☐ SMOULDER ☐ STEAM ☐ NONE

WHAT WAS MOISTURE CONTENT OF CONCENTRATES AT DISCHARGING PORT?

TOP LAYER _____ MIDDLE LAYER _____ BOTTOM LAYER _____

REMARKS: IN THIS SPACE THE MASTER IS REQUESTED TO INSERT ANY OTHER INFORMATION WHICH WOULD AID THE DEPARTMENT OF TRANSPORT IN LEARNING ABOUT THE BEHAVIOUR OF CONCENTRATES AT SEA.

_____ DATE

_____ SIGNATURE OF MASTER

(FRANÇAIS AU VERSO)

82-0529
0-68

List of Ore Concentrates Exported from Canada

The particle size distribution of a concentrate has a considerable influence upon the risk of reaching a flow state. Some concentrates may be so coarse that they will not be able to hold enough water between the particles to develop a flow state.

The list which follows, including values which are considered typical, is given for information only. Stowage factor corresponds to average moisture content. Angle of repose range is determined over the full range from zero moisture content to transportable moisture limit.

It should be noted that the transportable moisture limit applicable to each cargo should be determined as required by the Code. The angle of repose for each shipment should also be determined prior to loading so as to apply the relevant requirements of either section 3 or section 4. Masters should consult the Port Warden for full details of the cargo they are about to load.

CONCENTRATE TYPE	ORIGIN	ANGLE OF REPOSE RANGE	TRANS-PORTABLE MOISTURE LIMIT	AVERAGE MOISTURE CONTENT AT ORIGIN	STOWAGE FACTOR		SUMMARY OF PARTICLE SIZE DISTRIBUTION
					Ft^3 Ton	M^3 tonne	
Copper	Canada (Buchans Unit, Asarco, Buchans Nfld.) Botwood, Nfld.	36° – 40°	11.2%	9.3%	15.3		99% – 200 mesh 88% – 325 mesh
Copper	Canada (Heath Steel Mines Ltd.) Newcastle, N.B.	37° – 48°	11.9%	9.5%	15.2		97% – 200 mesh 90% – 325 mesh
Copper	Canada (Cupra Mines Limited) Quebec City	36° – 45°	11.4%	9.2%	19.6		90.3 % – 200 mesh
Copper	Canada (Canadian Jamieson Mines Limited) Trois Rivières, Qué.	36° – 48°	10.0%	8.6%	16.0		90% – 325 mesh
Copper	Canada (Coppercorp Mine) Sault Ste. Marie, Ont.	33° – 46°	14.9%	9.1%	15.2		8% + 100 mesh 24% + 200 mesh 17% + 325 mesh 51% – 325 mesh
Copper	Canada (Western Mines Ltd.) Campbell River, B.C.	36° – 48°	10.4%	7.0%	15.3		70% – 400 mesh
Copper	Canada (Bethlehem Copper Corp. Ltd.) Vancouver, B.C.	34° – 49°	10.5%	7.3%	18.0		100% – 65 mesh 35% – 400 mesh
Copper	Canada (Coast Copper Company Ltd.) Vancouver Island, B.C.	36° – 48°	9.4%	7.8%	14.0		1.5% + 100 mesh 72% – 325 mesh

Copper	Canada (Craigmont Mines Ltd.) Vancouver, B.C.	39° – 52°	10.1%	8.0%	15.5	0.5% + 65 9.8% + 270 1.5% + 100 8.6% + 325 3.9% + 150 5.0% + 400 9.0% + 200 61.7% – 400
Copper	Canada (Anaconda Co. (Canada) Ltd.) Britannia Beach, B.C.	34° – 47°	10.4%	10.0%	15.2	100% – 65 mesh 80% – 300 mesh
Copper	Canada (Texada Mines Ltd.) Texada Island, B.C.	31° – 46°	9.9%	6.8%	13.5	17.1% + 100 mesh 27.9% + 200 mesh 18.8% + 325 mesh 36.2% – 325 mesh
Copper	Canada (The Granby Mining Co. Ltd., Grand Forks) Vancouver, B.C.	37° – 48°	9%	7.5%	16.7	100% – 48 mesh 4% + 100 mesh 81% – 200 mesh 65% – 325 mesh
Copper	Canada (Wedge Mine, Cominco Ltd.) Dalhousie, N.B.	41° – 48°	11.1%	8.4%	13.3	3.0% + 200 mesh 7.0% + 325 mesh 90.0% – 325 mesh
Copper	Canada (Munro Copper Mines, Matheson Ont.) Quebec City, Que.	37° – 44°	10.9%	7.66%	14.0	100% – 60 mesh 99.75% – 100 mesh 94.75% – 150 mesh 90.25% – 250 mesh
Copper	Canada (New Imperial Mines Ltd.) North Vancouver, B.C.	37° – 44°	9%	4% – 8%	15.2	Not available
Copper	Canada (Wesfrob Mines Ltd.) Tasu, B.C.	38° – 48°	10.2%	11.5%	13.0	100% – 1680 micron 85% – 44 micron
Copper	Canada (Granisle Copper Limited) Prince Rupert, B.C.	29° – 35°	10.6%	7.8%	16.7	2% + 100 mesh 88% – 200 mesh

APPROXIMATE VALUES ONLY (See the note introducing this annex)

CONCENTRATE TYPE	ORIGIN	ANGLE OF REPOSE RANGE	TRANS-PORTABLE MOISTURE LIMIT	AVERAGE MOISTURE CONTENT AT ORIGIN	STOWAGE FACTOR		SUMMARY OF PARTICLE SIZE DISTRIBUTION
					Ft^3 Ton	M^3 tonne	
Nickel-Copper	Canada (Giant Mascot Mines) Vancouver, B.C.	36° – 52°	10.8%	9.6%	14.0		0.2% + 48 mesh 1.0% + 65 mesh 4.0% + 100 mesh 6.4% + 150 mesh 9.8% + 200 mesh 78.6% – 200 mesh
Chalcopyrite	Canada (Copperfield Mining Corporation Ltd.) Montreal, Que.	37° – 52°	10.0%	7.7%	15.3		12% + 100 mesh 62% – 200 mesh
Iron (Magnetite)	Canada (Coast Copper Company Ltd.) Vancouver Island, B.C.	40° – 46°	9.1%	7.5%	13.9		4.8% + 100 mesh 70% – 200 mesh 46% – 325 mesh
Iron	Canada (Iron Ore Company of Canada) Sept Isles, Que.	37° – 50°	9.0%	4.5%	13.0		100% – 10 mesh 48% + 80 mesh 80% + 150 mesh
Iron	Canada (Texada Mines Ltd.) Texada Island, B.C.	40° – 44°	7.1%	5.5%	13.1		0.1% + 10 mesh 29.0% + 48 mesh 27.9% – 48 + 100 mesh 43.1% – 100 mesh
Iron	Canada (Jedway Iron Ore Ltd.) Harriet Harbour, Queen Charlotte Island, B.C.	38° – 48°	7.4%	5.8%	12.3		100% – 3/8 inches 30-37% – 100 mesh
Iron (Sinter Feed)	Canada (Wesfrob Mines Limited) Tasu, Queen Charlotte Island, B.C.	40° – 45°	9.8%	4.6%	12.0		100% – 4000 micron 30% – 149 micron

Iron (Pellet feed)	Canada (Wesfrob Mines Limited) Tasu, Queen Charlotte Island, B.C.	35° – 51°	9.6%	8.0%	12.1	100% - 1680 micron 80% - 44 micron
Iron (Magnetite)	Canada (Zeballos Iron Mines Ltd.) Zeballos, Vancouver Island, B.C.	36° – 42°	Not applied due to particle size		10.9	100% - 6 inches 60% + 1/4 inch
Iron	Canada (Brynnor Mines Ltd, Kennedy Lake Div.) Toquart Bay, Vancouver Island, B.C.	39° – 40°	7.1%	5.9%	11.4	99.2% - 10 mesh 38.2% - 100 mesh
Iron	Canada (Quebec Cartier Mining Co.) Port Cartier, Que.	35° – 51°	8.2%	1% – 4%	12.3	100% - 8 mesh 24% + 20 mesh 94% + 100 mesh
Lead	Canada (Buchans Unit, Asarco, Buchans Nfld.) Botwood, Nfld.	34° – 47°	7.9%	5.5%	10.6	99% - 200 mesh 95% - 325 mesh
Lead	Canada (Heath Steel Mines Ltd.) Newcastle, N.B.	30° – 48°	10.1%	8.0%	14.2	98% - 200 mesh 92% - 325 mesh
Lead	Canada (Cupra Mines Ltd.) Quebec City, Que.	37° – 46°	10.5%	5.0%	21.5	98.7% - 200 mesh
Lead	Canada (Ecstall Mining) Quebec City, Que.	39° – 45°	10.9%	10.8%	12.0	99% - 325 mesh
Lead	Canada (Cominco Sullivan) New Westminster, B.C.	36° – 40°	7.5%	9%	14.2	99.4% - 200 mesh 91.8% - 325 mesh
Lead	Canada (Pine Point Mines Ltd.) New Westminster, B.C.	40° – 48°	6.9%	5.5%	12.2	85.9% - 325 mesh 2.0% + 200 mesh

APPROXIMATE VALUES ONLY (See the note introducing this annex)

CONCENTRATE TYPE	ORIGIN	ANGLE OF REPOSE RANGE	TRANS-PORTABLE MOISTURE LIMIT	AVERAGE MOISTURE CONTENT AT ORIGIN	STOWAGE FACTOR		SUMMARY OF PARTICLE SIZE DISTRIBUTION
					Ft^3 Ton	M^3 tonne	
Lead	Canada (Brunswick Mining and Smelting Corp. Ltd.) Dalhousie, N.B.	35° – 42°	11.3%	7.3%	17.0		29 microns
Lead/Silver	Canada (Dresser Minerals) Walton, N.S.	40° – 50°	9.2%	11.5%	12.0		85% – 200 mesh
Pyrite	Canada (Anaconda Co. Canada Ltd.) Britannia Beach, B.C.	36° – 45°	9.0%	8.0%	16.4		100% – 48 mesh 60% – 200 mesh
Zinc	Canada (Buchans Unit, Buchans Nfld.) Botwood, Nfld.	38° – 47°	10.1%	7.4%	14.6		98% – 200 mesh 84% – 325 mesh
Zinc	Canada (Mattagami Lake Mines Ltd.) Quebec City, Que.	35° – 50°	10.4%	4.4%	16.5		90/92% – 200 mesh
Zinc	Canada (Normetal Mining Corporation Ltd.) Quebec City, Que.	37° – 47°	10.4%	10.2%	20.0		2.7% + 100 mesh 78.9% – 200 mesh
Zinc	Canada (Cupra Mines Limited) Quebec City, Que.	35° – 50°	10.9%	8.5%	12.9		90.3% – 200 mesh
Zinc (Containing silver)	Canada (Ecstall Mining Ltd.) Quebec City, Que.	35° – 47°	11.6%	5.8%	17.0		99% – 325 mesh
Zinc	Canada (Western Mines Ltd.) Campbell River, Vancouver Island, B.C.	38° – 46°	10.2%	6.7%	16.3		60% – 400 mesh

Zinc	Canada (Anaconda Company (Canada) Ltd.) Britannia Beach, B.C.	40° – 49°	9.6%	10 %	16.4		100% – 65 mesh 80% – 300 mesh
Zinc	Canada (Cominco Sullivan) New Westminster, B.C.	41° – 52°	9.1%	11 %	16.3		90.8% – 200 mesh 77.4% – 325 mesh
Zinc	Canada (Pine Point Mines Ltd.) New Westminster, B.C.	36° – 50°	9.7%	4.8%	18.9		55.7% – 325 mesh 24.0% + 200 mesh
Zinc	Canada (Lake Dufault Mines, Ltd.) Quebec City, Que.	37° – 48°	9.8%	6%	22.0		3% + 200 mesh 14% + 325 mesh 83% – 325 mesh
Zinc	Canada (Brunswick Mining and Smelting Corp. Ltd.) Dalhousie, N.B.	38° – 43°	12.9%	6.9%	19.0		32 microns

APPROXIMATE VALUES ONLY (See the note introducing this annex)